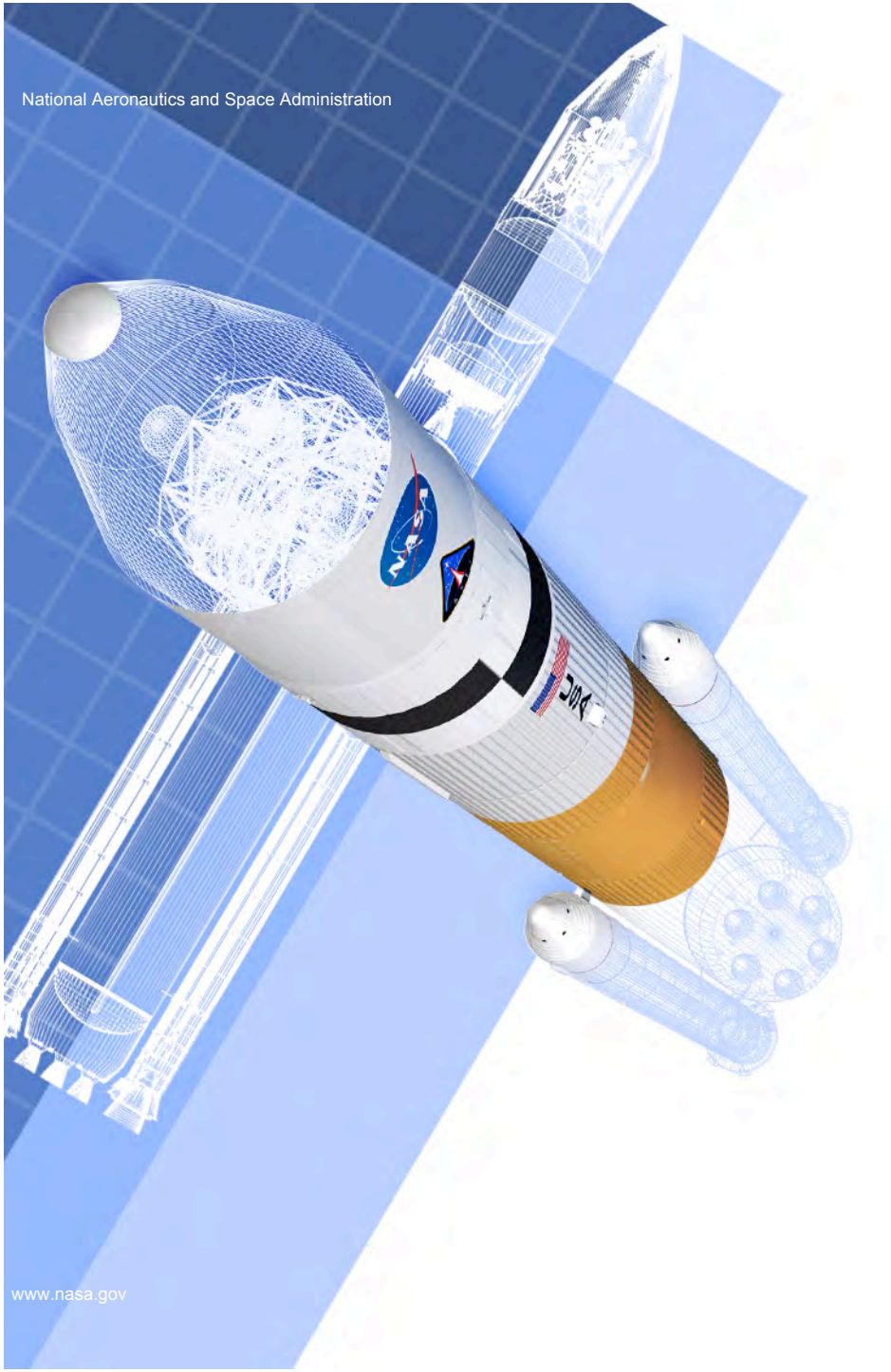


Lunar Program Industry Briefing:
Ares V Overview

Steve Cook
Manager, Ares Projects Office

Ares Projects Overview

- **Deliver crew and cargo for missions to International Space Station (ISS), the Moon and beyond**
- **Continuing progress toward design, component testing, and early flight testing**
- **Ares I Crew Launch Vehicle**
  - Carries 6 crew to ISS, 4 to Moon
  - First flight test scheduled in 2009
  - Initial Operational Capability in 2015
- **Ares V Cargo Launch Vehicle**
  - Launches Earth Departure Stage (EDS), Altair and Orion to Low Earth Orbit for lunar missions
  - Largest launch vehicle ever designed
  - Ongoing concept design work leading into detailed development work starting in 2011
  - First flight test planned in 2018

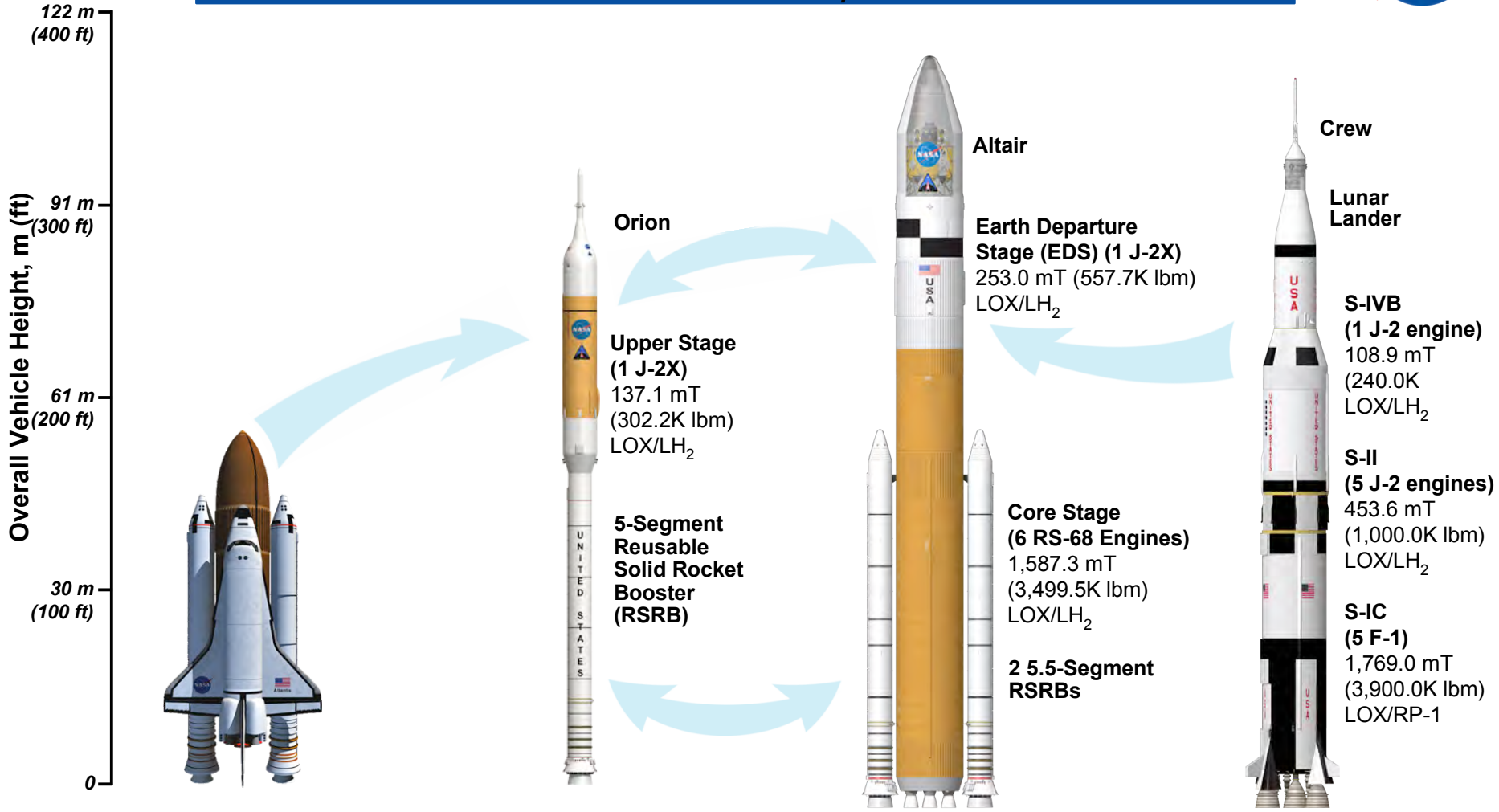
Ares V Cargo Launch Vehicle

Heavy Lift for Science and Exploration

- **Key transportation system for exploration beyond Low Earth Orbit**
  - Offers unique payload capabilities opening new doors to human exploration on the Moon and beyond
  - Designed for routine crew and cargo transportation to the Moon
    - **EDS + Altair to LEO**
    - **EDS + Altair + Orion to TLI**
  - Considered national asset creating new opportunities for science, national security and space business
  - Capable of transporting more than 71 metric tons to the Moon
  - Focal point for design and development located at MSFC with support across the Agency

Building on a Foundation of Proven Technologies

Launch Vehicle Comparisons



Space Shuttle

Height: 56.1 m (184.2 ft)
Gross Liftoff Mass:
2,041.1 mT (4,500.0K lbm)
Payload Capability:
25.0 mT (55.1K lbm) to
Low Earth Orbit (LEO)

Ares I

Height: 99.1 m (325.0 ft)
Gross Liftoff Mass:
927.1 mT (2,044.0K lbm)
Payload Capability:
25.5 mT (56.2K lbm)
to LEO

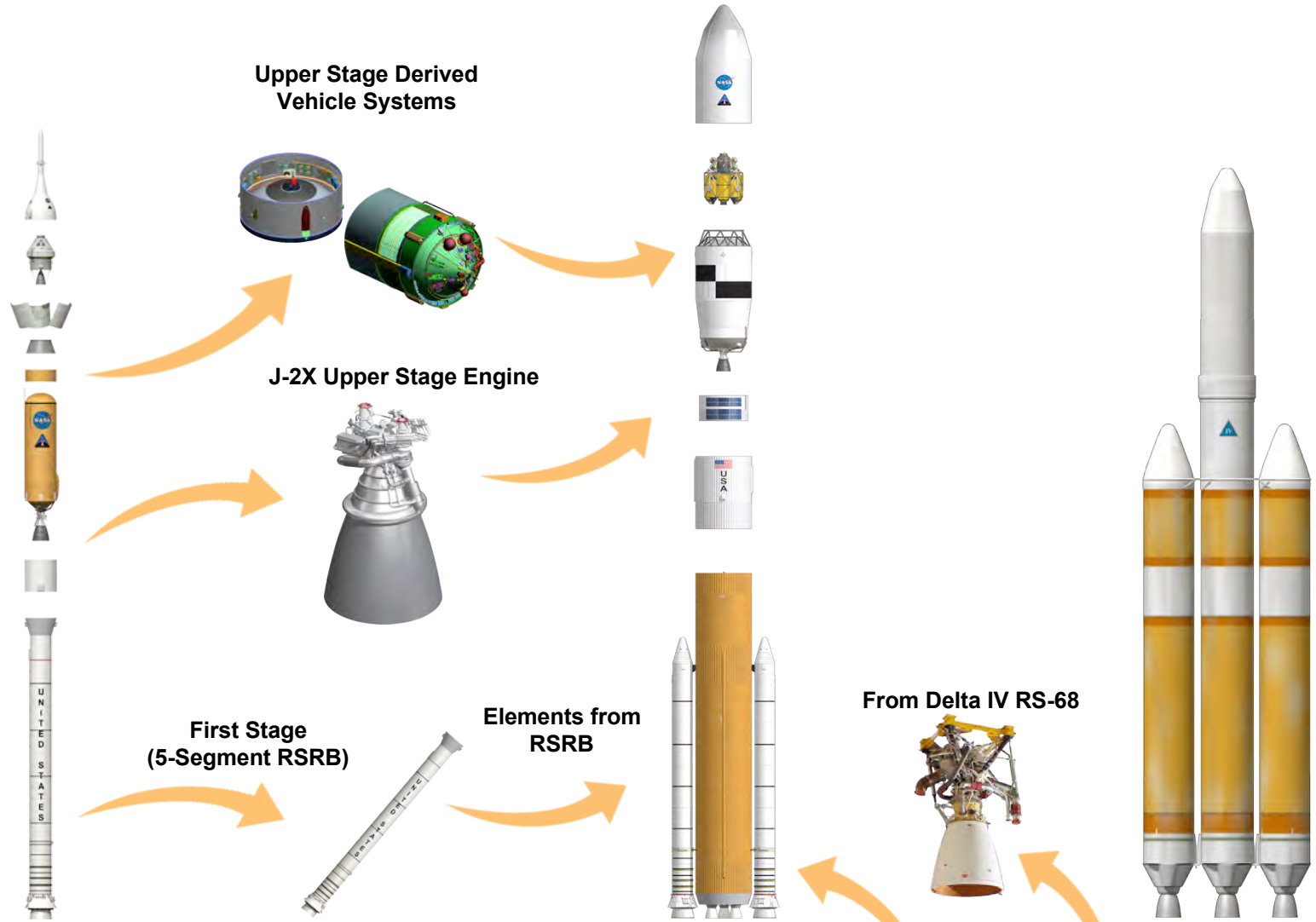
Ares V

Height: 116.2 m (381.1 ft)
Gross Liftoff Mass:
3,704.5 mT (8,167.1K lbm)
Payload Capability:
71.1 mT (156.7K lbm) to TLI (with Ares I)
62.8 mT (138.5K lbm) to Direct TLI
~187.7 mT (413.8K lbm) to LEO

Saturn V

Height: 110.9 m (364 ft)
Gross Liftoff Mass:
2,948.4 mT (6,500K lbm)
Payload Capability:
44.9 mT (99K kbm) to TLI
118.8 mT (262K lbm) to LEO

Ares V Element Heritage

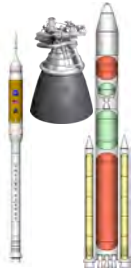
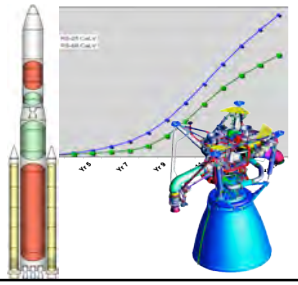
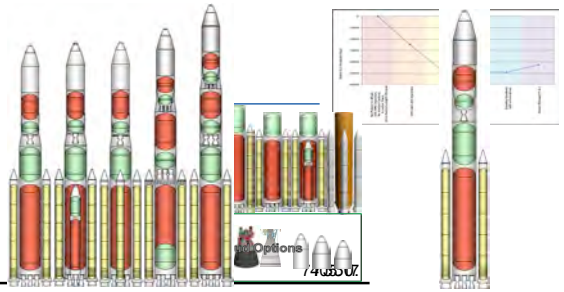
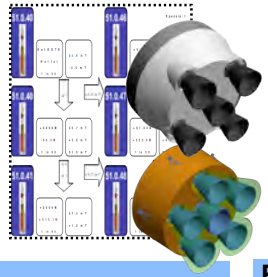
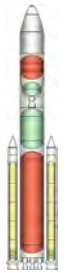


Ares I
25.5 t (56.2K lbm) to
Low Earth Orbit (LEO)

Ares V
71.1 t (156.7K lbm) to TLI (with Ares I)
63.0 t (138.5K lbm) to Direct TLI
187.7 t (413.8K lbm) to LEO

Delta IV

ESAS to LCCR Major Events

Original ESAS Capability

- *45.0 mT Lander*
- *20.0 mT CEV*
- *No Loiter in LEO*
- *8.4m OML*
- *5 SSMEs / 2J2S*

CY-06 Budget Trade to Increase

- Ares I / Ares V Commonality
- Ares I : 5 Seg RSRB / J2-X instead of Air-Start SSME
- Ares V: 1 J2-X

Detailed Cost Trade of SSME vs RS-68

- ~$4.25B Life Cycle Cost Savings for
- 5 Engine Core
- Increased Commonality with Ares I Booster
- 30-95 Day LEO Loiter Assessed

IDAC 3 Trade Space

- Lunar Architecture Team 1/2 (LAT) Studies
- Mission Delta V's increased
- Increase Margins From TLI Only to Earth through TLI
- Loiter Penalties for 30 Day Orbit Quantified

EDS Diameter Change from 8.4m to 10m

- Lunar Architecture Team 1/2 (LAT) Studies
- Lunar /Mars Systems Benefits
- Tank Assembly Tooling Commonality

Incorporate Ares I Design Lessons Learned / Parameters

- Core Engine / SRB Trades to Increase Design Margins
- Increase Subsystem Mass Growth Allowance (MGA)

Recommended Option

- *6 Core Engines*
- *5.5 Segment PBAN*

Updated Capability

- 45.0t Lander
- 20.2t CEV
- ~6t Perf. Margin
- 4 Day LEO Loiter
- Ares I Common MGAs
- HTPB Decision End of FY09

220 Concepts Evaluated

320 Concepts Evaluated

730 Concepts Evaluated

460 Concepts Evaluated

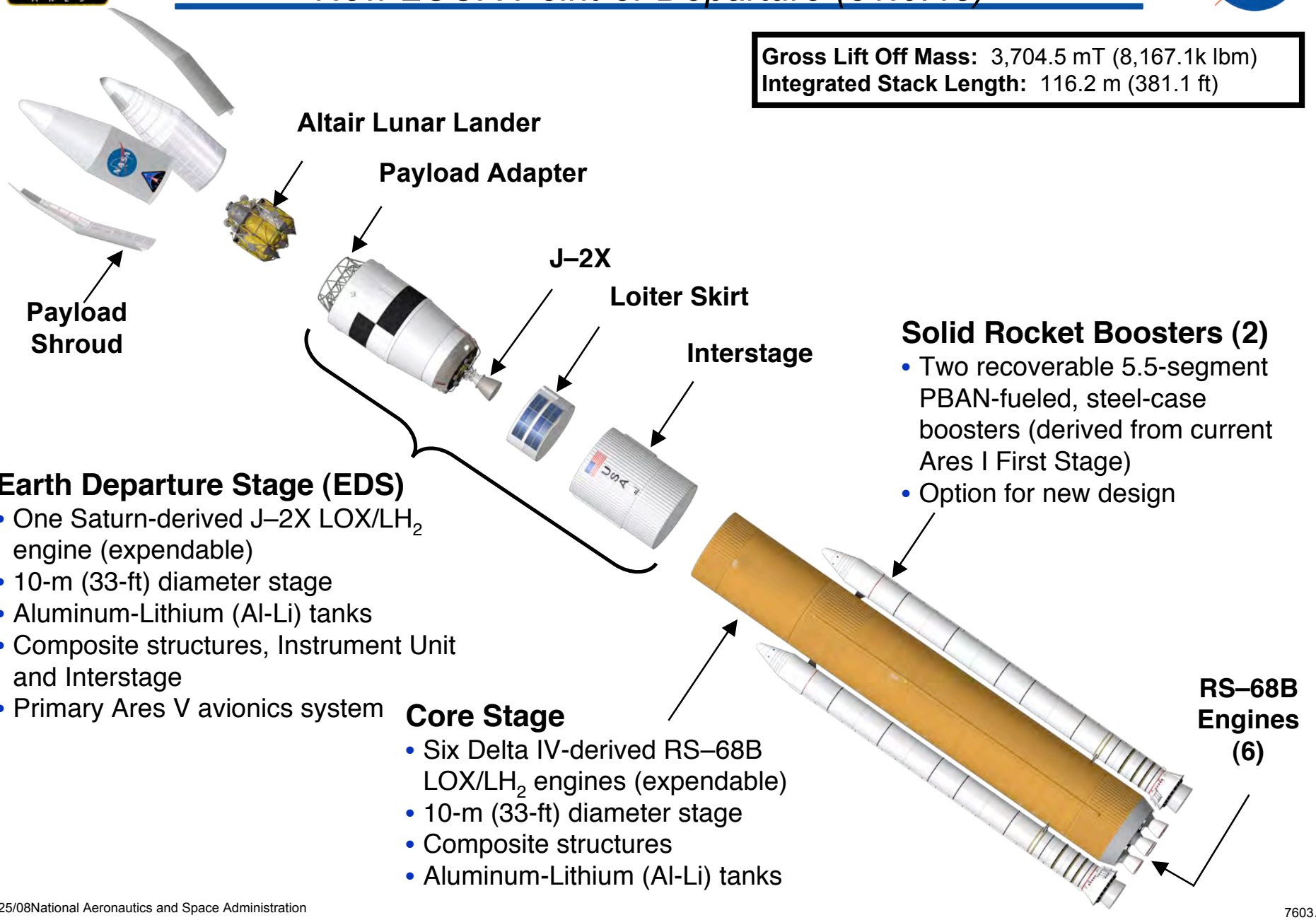
2005 | **2006** | **2007** | **2008**

ESAS Complete — **Ares I ATP** — **Orion ATP** — **Ares I SRR** — **Orion SRR** — **Ares I SDR** — **Ares V MCR**

Ares V Elements

New LCCR Point-of-Departure (51.0.48)

Gross Lift Off Mass: 3,704.5 mT (8,167.1k lbm)
Integrated Stack Length: 116.2 m (381.1 ft)



Earth Departure Stage (EDS)

- One Saturn-derived J–2X LOX/LH_2 engine (expendable)
- 10-m (33-ft) diameter stage
- Aluminum-Lithium (Al-Li) tanks
- Composite structures, Instrument Unit and Interstage
- Primary Ares V avionics system

Core Stage

- Six Delta IV-derived RS–68B LOX/LH_2 engines (expendable)
- 10-m (33-ft) diameter stage
- Composite structures
- Aluminum-Lithium (Al-Li) tanks

Solid Rocket Boosters (2)

- Two recoverable 5.5-segment PBAN-fueled, steel-case boosters (derived from current Ares I First Stage)
- Option for new design

Ares V Technology Needs

Nose Cone/Forward Skirt

Loaded Motor

Ares Value Stream

Key Technology Areas
Composites
Cryo Fluid Management
Solids
Automation
Liquid Propulsion
Control/Separation

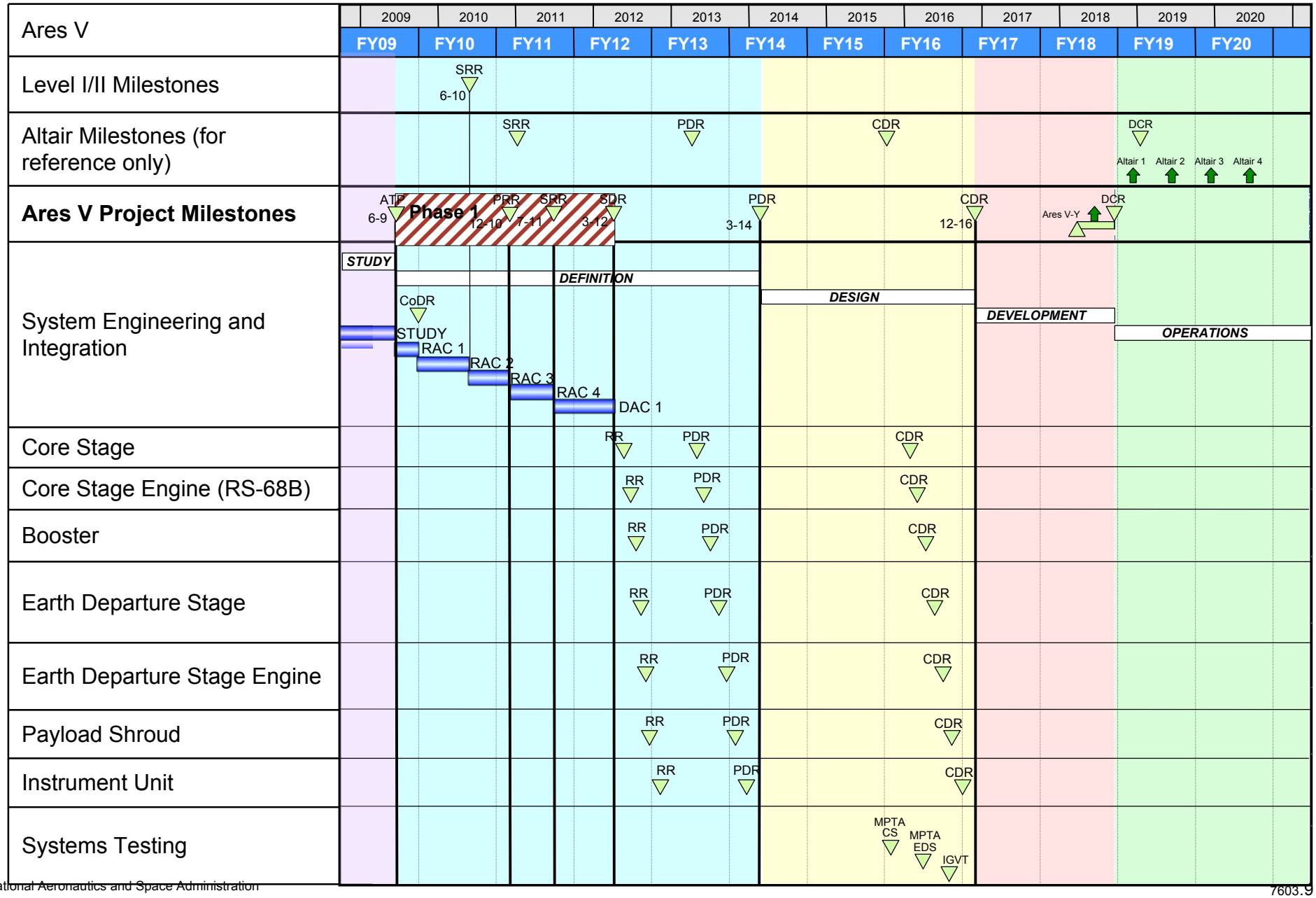
Core Stage Aft Skirt

Point of Departure Shroud (Biconic)

ETDP Technology Prioritization Process (TPP)

Ares V Technology Priorities
1. Large Composite Manufacturing
2. HTPB Propellant
3. Long Term CFM
4. Composite Damage Tolerance/Detection
5. EDS State Determination & Abort
6. Composite Joining Technology
7. Liquid Level Measurement
8. Multi Layer Insulation
9. Leak Detection
10. Non Autoclave Composites
11. SRM Composite Metal Technology
12. Composite Dry Structure Development
13. Composite Damage Failure Detection for Abort
14. Nozzle Sensitivity to Pocketing (High Heat Flux from HTPB)
15. LH2 Tank Micro Cracking

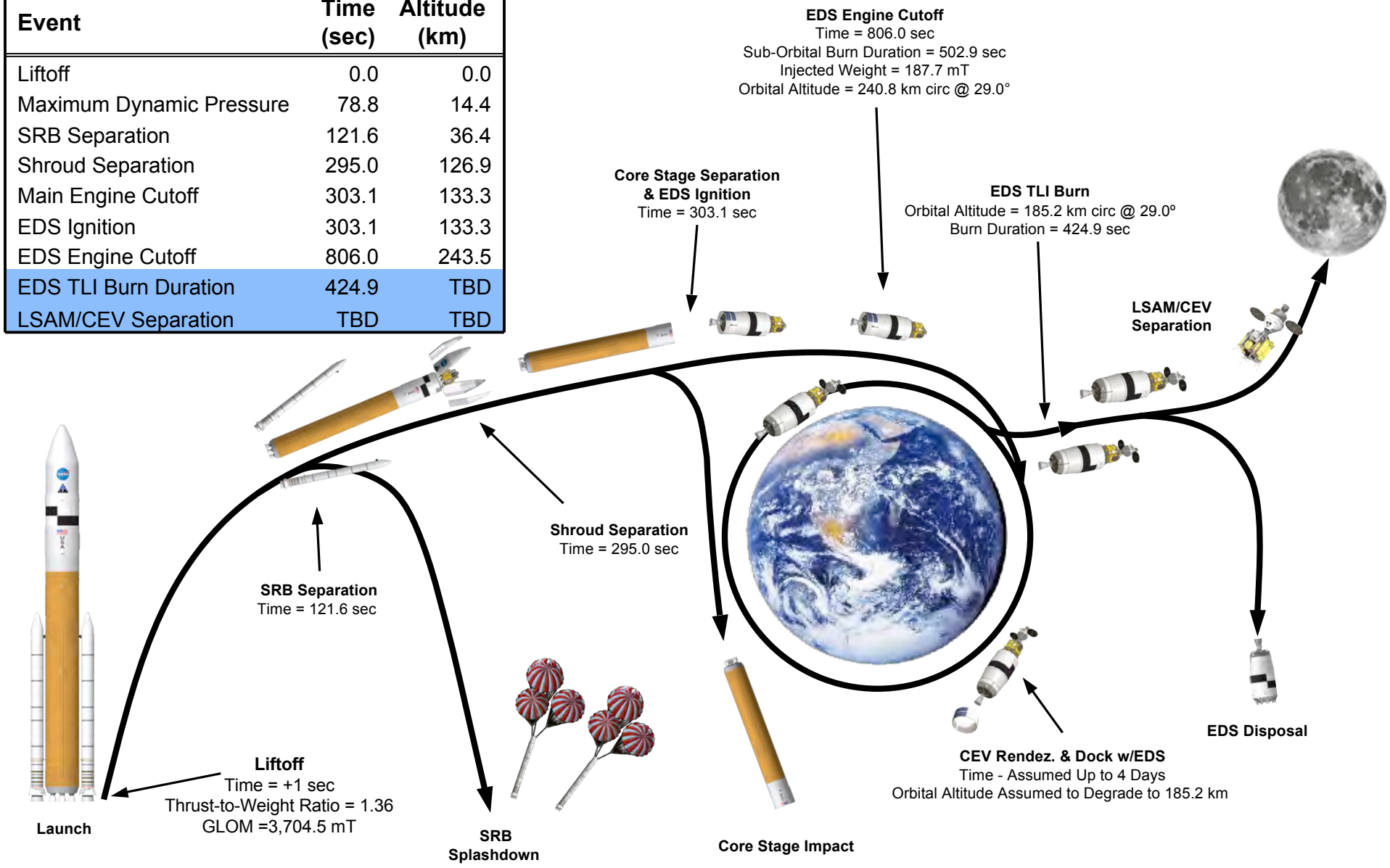
Ares V Summary Schedule



Ares V Profile

51.00.48 Recommended POD (Lunar Sortie)

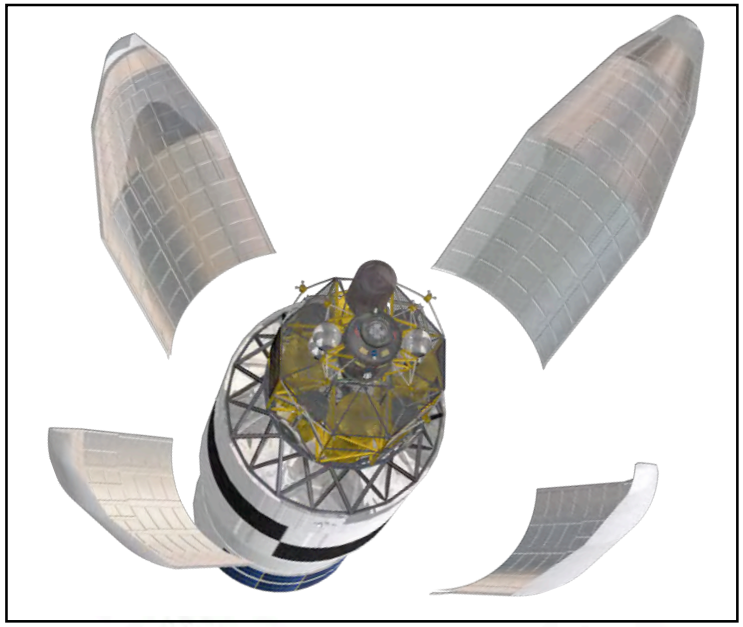
Event	Time (sec)	Altitude (km)
Liftoff	0.0	0.0
Maximum Dynamic Pressure	78.8	14.4
SRB Separation	121.6	36.4
Shroud Separation	295.0	126.9
Main Engine Cutoff	303.1	133.3
EDS Ignition	303.1	133.3
EDS Engine Cutoff	806.0	243.5
EDS TLI Burn Duration	424.9	TBD
LSAM/CEV Separation	TBD	TBD

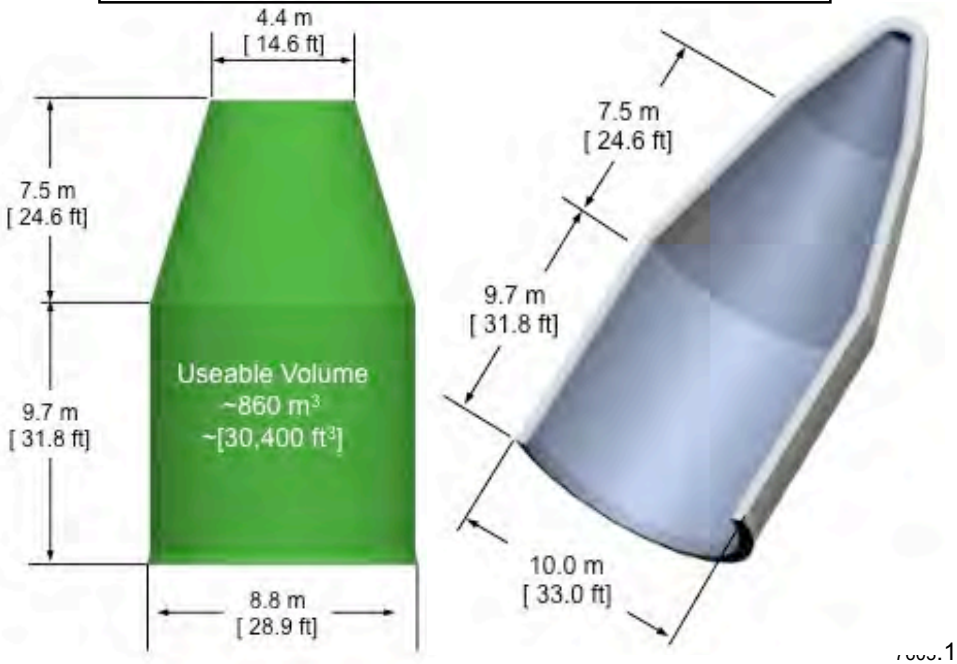


Payload Utilization

Ares V as a National Asset

- **Ares V offers the largest payload capability than all other existing launch vehicles**
  - Over 40% more lift capability than Saturn V
  - 3-5 times for volume than most other launch systems
- **These unique capabilities open new worlds and create unmatched opportunities**
  - Human exploration
  - Science
  - Space Business
- **Ares V is actively engaged with external organizations during this early concept phase to ensure its utilization for other missions**
  - National Security
  - Astronomy and Solar System Science





Our Achievements

Programmatic Milestones

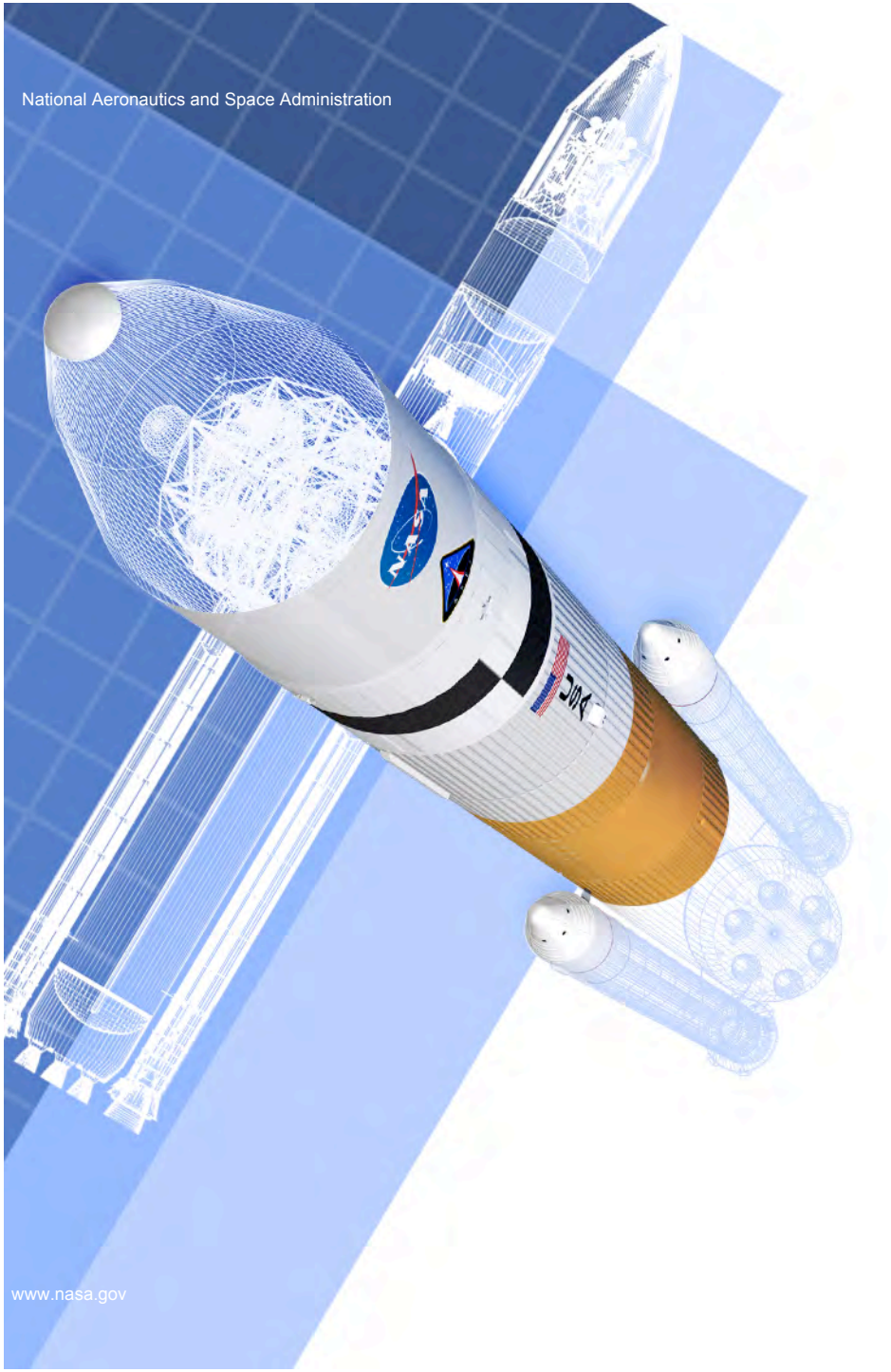
- Completed Ares I System Requirements Review (SRR) – Jan 2007
- Awarded contracts for Ares I First Stage, J-2X Engine, Upper Stage and Instrument Unit
- Completed Ares I System Definition Review (SDR) – Oct 2007
- Completed Ares V Mission Concept Review (MCR) – Jun 2008
- Completed Constellation Lunar Capability Concept Review (LCCR) – Jun 2008
- Released Ares V Request For Information (RFI) and evaluating responses – Aug 2008
- Completion of Ares I Preliminary Design Review (PDR) – Sep 2008

Technical Accomplishments

- Ares I Drogue Chute Drop Test – July 2008
- Ares I First Stage Separation and Re-entry Wind Tunnel Tests
- J-2X Injector and Power Pack Tests
- A-3 Test Stand Construction for J-2X Engine at Stennis Space Center
- MSFC Dynamic Test Stand 4550 Refurbishment for Ares I and Ares V Integrated Vehicle Ground Vibration Testing
- Established Ares V Design Concept Which Fully Supports the Constellation Architecture

Summary

- Key elements of Ares V are under development as a part of Ares I and the Air Force RS-68
- Ares V Point of Departure (POD) vehicle has ~ 40% more payload capability than Saturn V which closes the lunar architecture with 6 MT of margin to Trans-Lunar Injection (TLI)
- Ares V concept design and development is underway
- Ares V completed its Mission Concept Review (MCR) in June of this year and is proceeding into Phase A
- Industry involvement in Ares V Phase I will support element definition to assure robust system level requirements
- After System Definition Review (SDR) timeframe Ares V element prime contract awards will begin Phase II


National Aeronautics and Space Administration
www.nasa.gov

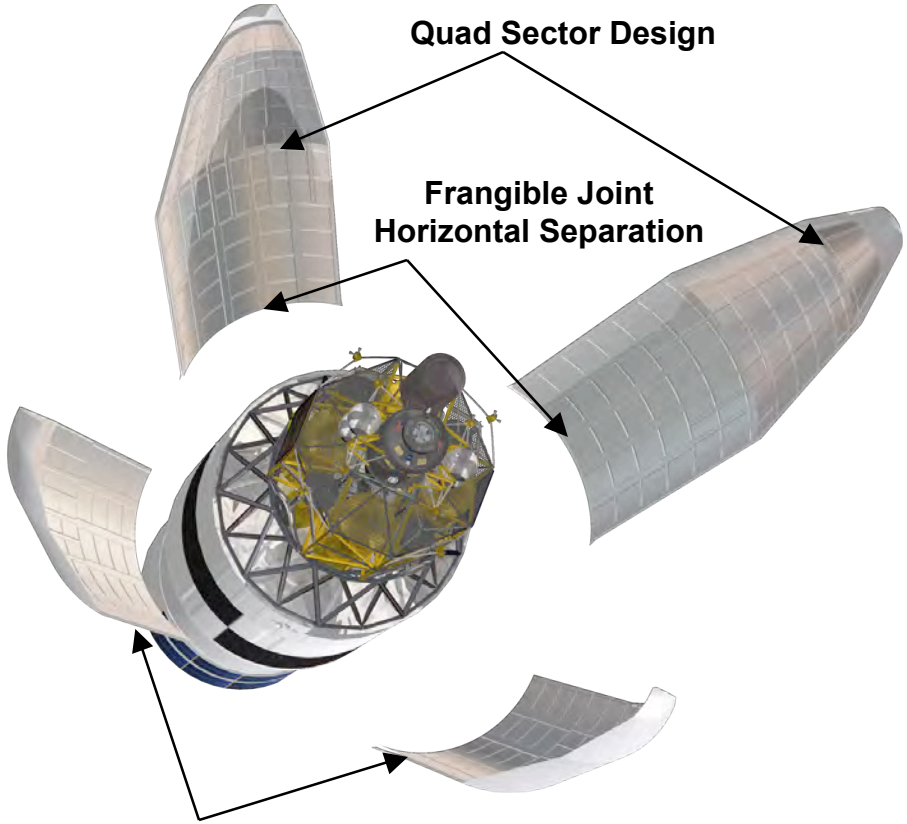
Backup

Payload Shroud Design Concept

Point of Departure (Biconic)

Leading Candidate (Ogive)

Mass: 9.1 t (20.0k lbm)
POD Geometry: Biconic
Design: Quad sector
Barrel Diameter: 10 m (33 ft)
Barrel Length: 9.7 m (32 ft)
Total Length: 22 m (72 ft)

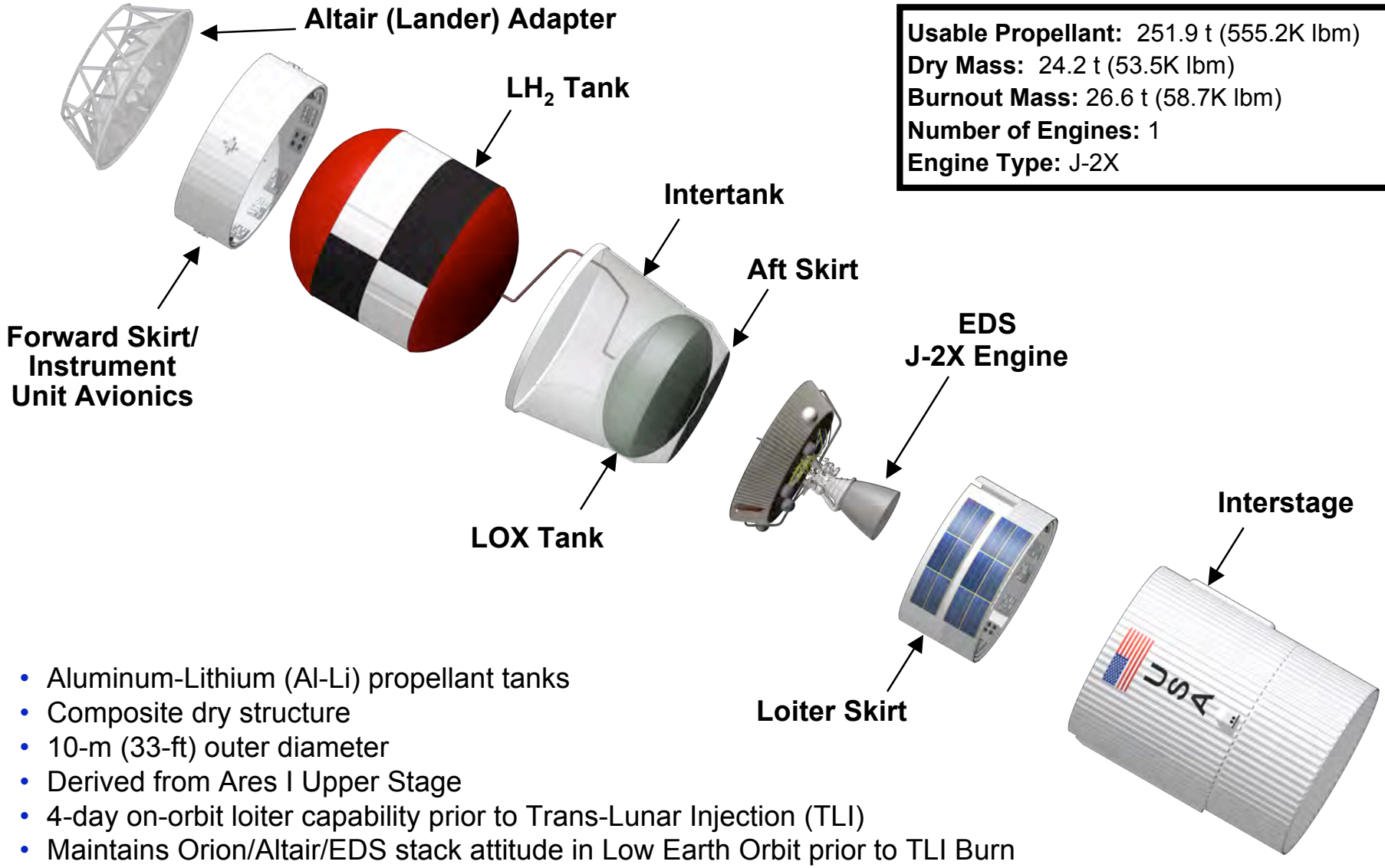


- Composite sandwich construction (Carbon-Epoxy face sheets, Al honeycomb core)
- Painted cork TPS bonded to outer face sheet with RTV
- Payload access ports for maintenance, payload consumables and environmental control (while on ground)

Thrust Rail Vertical Separation System
Payload umbilical separation

Earth Departure Stage Current Design Concept

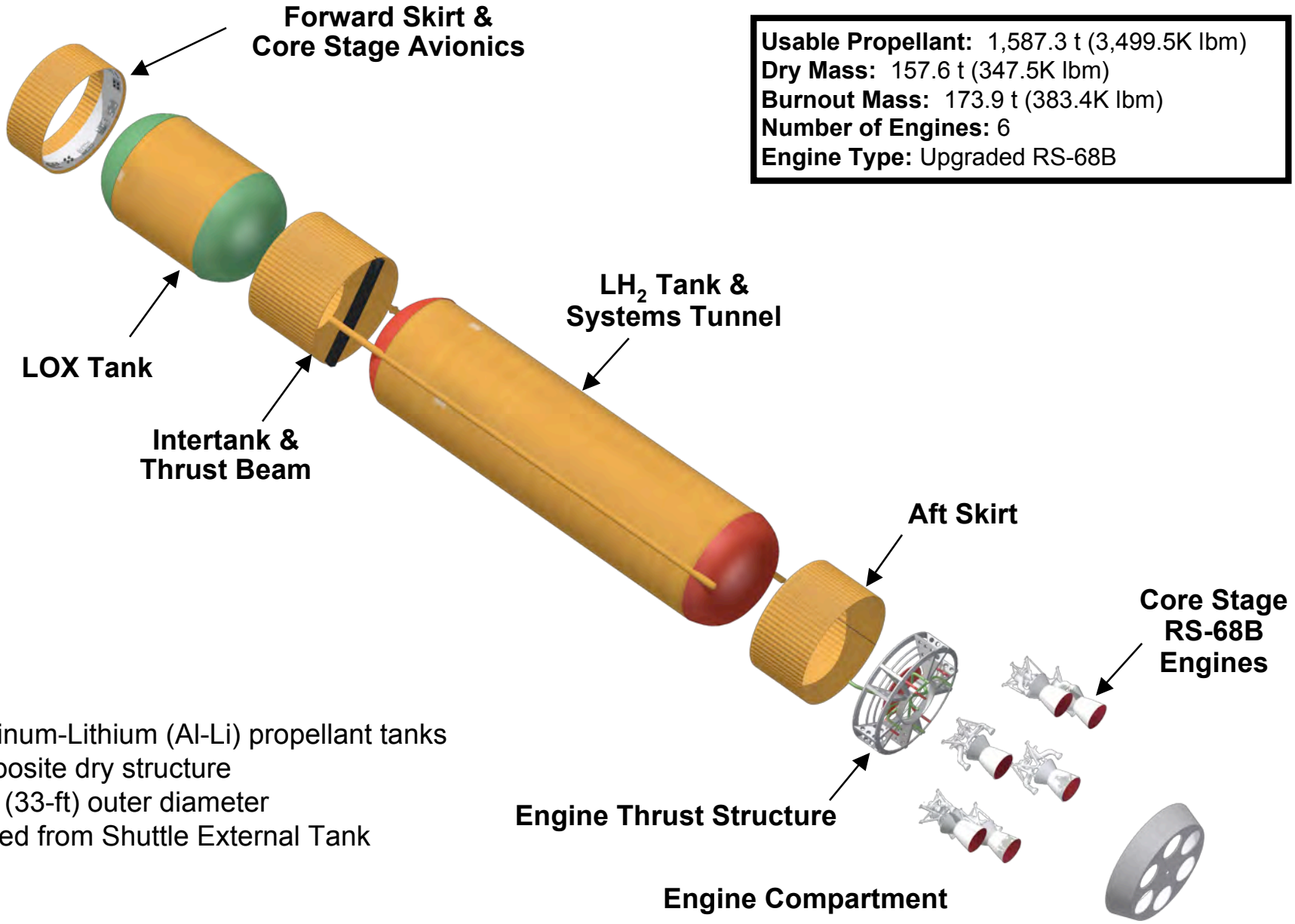
Expanded View



Usable Propellant: 251.9 t (555.2K lbm)
Dry Mass: 24.2 t (53.5K lbm)
Burnout Mass: 26.6 t (58.7K lbm)
Number of Engines: 1
Engine Type: J-2X

- Aluminum-Lithium (Al-Li) propellant tanks
- Composite dry structure
- 10-m (33-ft) outer diameter
- Derived from Ares I Upper Stage
- 4-day on-orbit loiter capability prior to Trans-Lunar Injection (TLI)
- Maintains Orion/Altair/EDS stack attitude in Low Earth Orbit prior to TLI Burn
- Provides 1.5 kW of power to Altair from launch to TLI

Core Stage Current Design Concept
- Expanded View -



Usable Propellant: 1,587.3 t (3,499.5K lbm)
Dry Mass: 157.6 t (347.5K lbm)
Burnout Mass: 173.9 t (383.4K lbm)
Number of Engines: 6
Engine Type: Upgraded RS-68B

- Aluminum-Lithium (Al-Li) propellant tanks
- Composite dry structure
- 10-m (33-ft) outer diameter
- Derived from Shuttle External Tank

Earth Departure Stage J-2X Engine

Turbomachinery
• Based on J–2S MK–29 design

Gas Generator
• Based on RS–68 design

Engine Controller
• Based directly on RS–68 design and software architecture

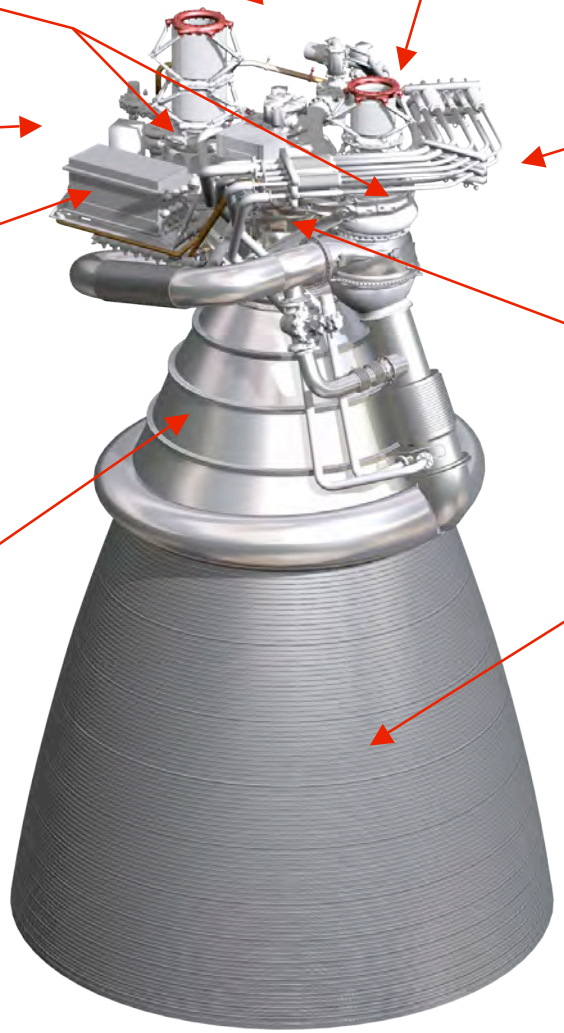
Regeneratively Cooled Nozzle Section
• Based on long history of RS–27 success

Flexible Inlet Ducts
• Based on J–2 & J–2S ducts

Open-Loop Pneumatic Control
• Similar to J–2

HIP-bonded MCC
• Based on RS–68 demonstrated technology

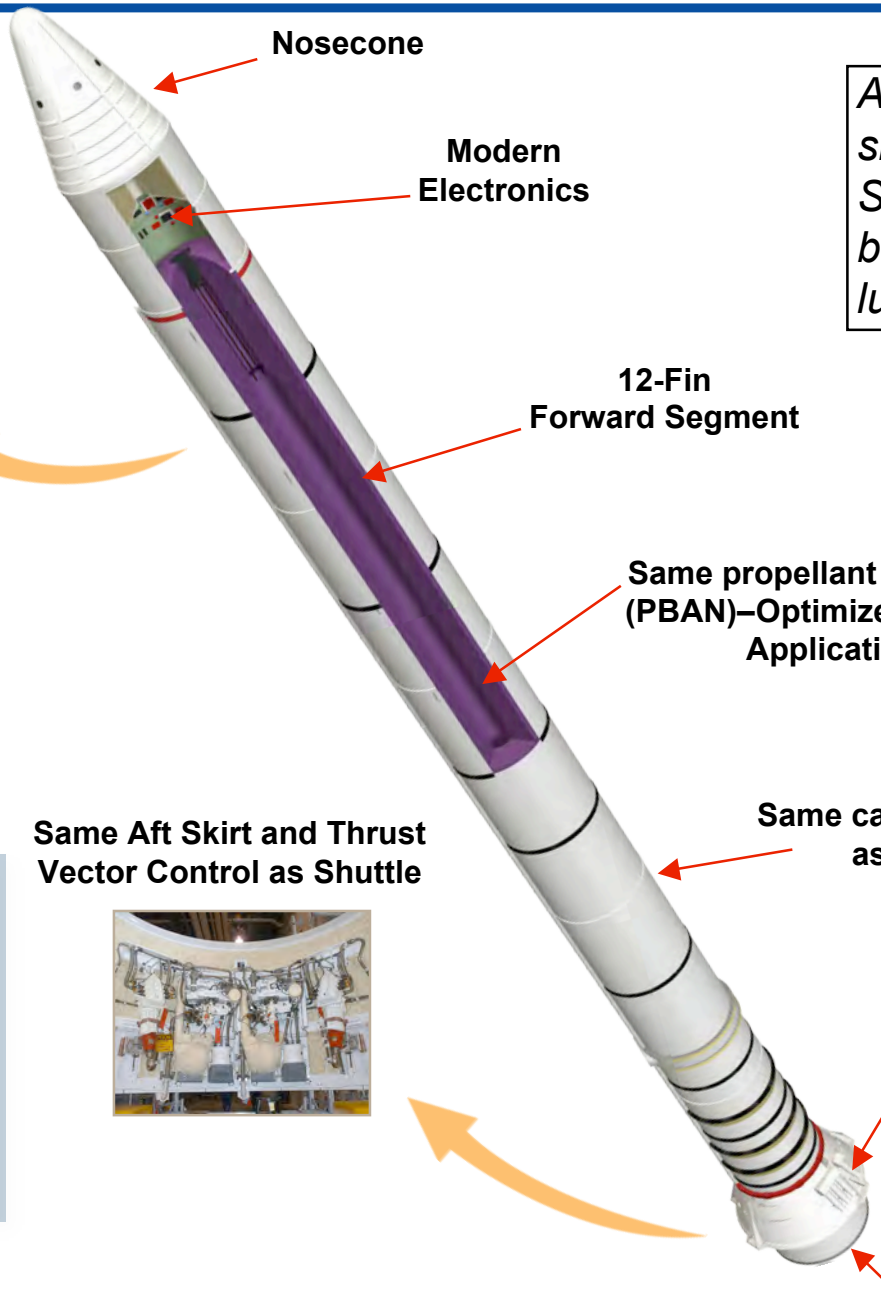
Nozzle Extension



Mass: 2.5 t (5,450 lbm)
Thrust: 1,300 kN (294k lbf) @ vac (100%)
Isp: 448 sec @ vac (100%)
Height: 4.7 m (185 in)
Diameter: 3.0 m (120 in)

Essentially identical to Ares I
• **Earth orbit loiter**
• **On-orbit restart**

Ares V Solid Rocket Booster (SRB)



Ares V SRB is similar to Space Shuttle and Ares I but optimized for lunar missions

Same Aft Skirt and Thrust Vector Control as Shuttle

Each Booster:

Mass: 791.5 t (1,744.9K lbm)

Thrust: 16.86 MN (3.79M lbf)

Burn Duration: 126 sec

Height: 59 m (193 ft)

Diameter: 3.7 m (12 ft)

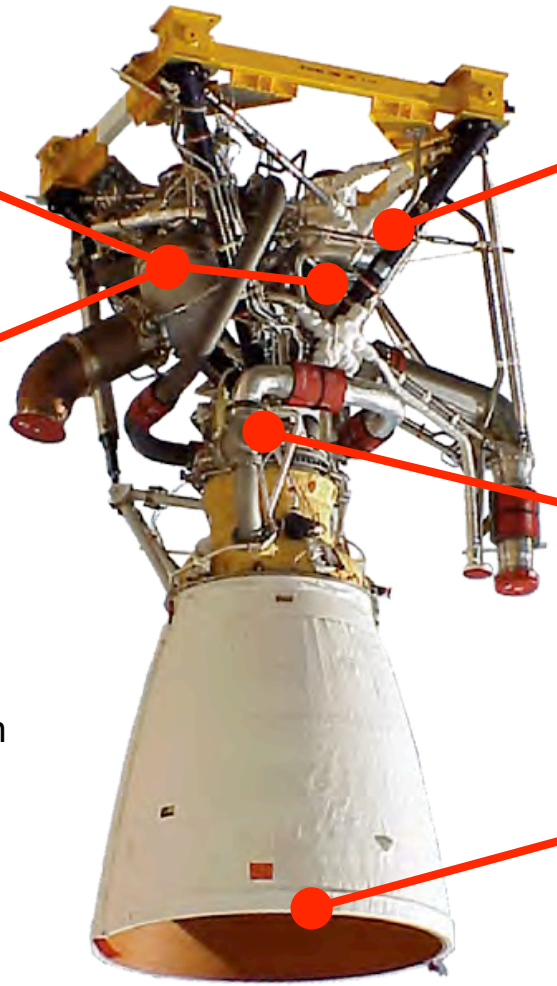
Core Stage Upgraded USAF RS-68B Engine

* Redesigned turbine nozzles to increase maximum power level by ≈ 2%

Redesigned turbine seals to significantly reduce helium usage for pre-launch

Other RS-68A upgrades or changes that may be included:

- Bearing material change
- New Gas Generator igniter design
- Improved Oxidizer Turbo Pump temp sensor
- Improved hot gas sensor
- 2nd stage Fuel Turbo Pump blisk crack mitigation
- Cavitation suppression
- ECU parts upgrade



Helium spin-start duct redesign, along with start sequence modifications, to help minimize pre-ignition free hydrogen

* Higher element density main injector improving specific impulse

Increased duration capability ablative nozzle

* **RS-68A Upgrades**